Using External Interrupts from Digital Lines

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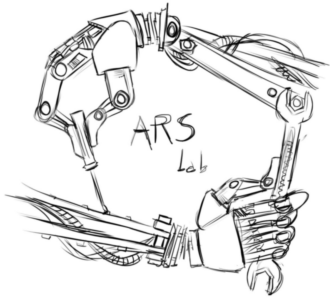

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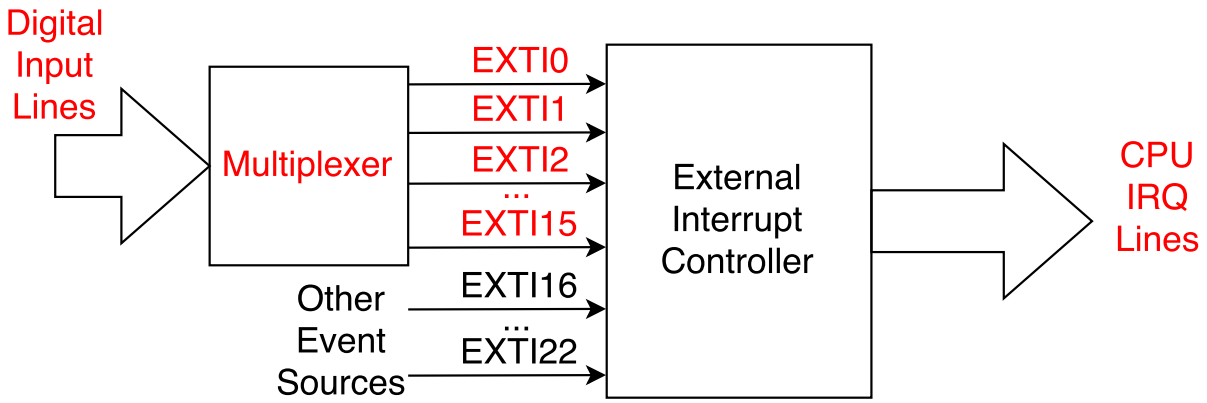
Digital Lines and Interrupts

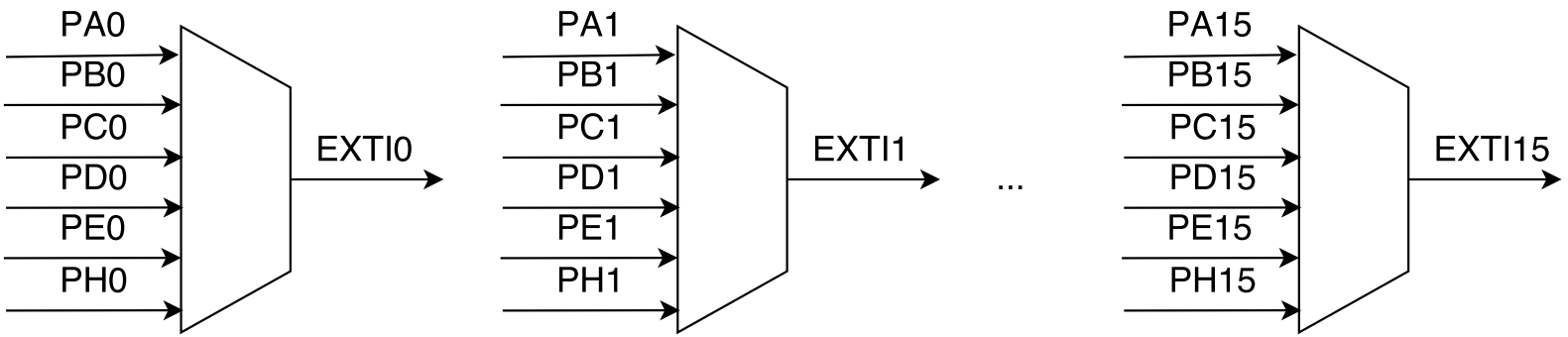
- Each digital input line can trigger an **IRQ**
- The **IRQ** can be configured to be triggered on:
  - **falling edge** (transition "1-to-0")
  - **rising edge** (transition "0-to-1")
  - **both edges**
- The circuit that handles the configuration is called **External Interrupt Controller (EXTI)**

External Interrupt



- The **External Interrupt Controller** handles (internally) **23 interrupt lines**, called **`EXTI0, EXTI1, ..., EXTI22`**
- Lines **`EXTI0, ..., EXTI15`** can be connected to GPIO digital inputs through a multiplexer, so **at most** 16 digital inputs can be used, at the same time, as interrupt sources
- Lines **`EXTI15, ..., EXTI22`** are internally connected to interrupt sources from other peripherals

The Multiplexer



- The **EXTI muliplexer** configures the **input source** for each EXTI line
- Each **`EXTIx`** line can be connected to pin **x** of **only one** GPIO

Using EXTI Interrupts

1. Configure the multiplexer in order to connect a **`GPIO`** pin to a **`EXTI`** line
2. Configure the **`EXTI`** line to handle the interrupt by specifying the **signal edge**:
   - **falling edge**
   - **rising edge**
   - **both edges**
3. Write the **Interrupt Service Routine** relevant to the EXTI line: there you must handle the interrupt and then cancel it by means of a proper function call

stm32_unict_lib EXTI functions

- Configure the multiplexer:

```
void GPIO_config_EXTI(GPIO_TypeDef * gpio,
                      EXTI_line exti);
```

  - `gpio` is the port, i.e. **`GPIOA`**, **`GPIOB`**, ...
  - `exti` represents the EXTI line, i.e. one of the constants **`EXTI0`**, **`EXTI1`**, ..., **`EXTI15`**

- Enable an EXTI line by configuring the edge:

```
void EXTI_enable_EXTI(EXTI_line exti,
                      edge_type edge);
```

  - `exti` represents the EXTI line, i.e. one of the constants **`EXTI0`**, **`EXTI1`**, ..., **`EXTI15`**
  - `edge` represents the edge, i.e. one of the constants **`RISING_EDGE`**, **`FALLING_EDGE`**, **`BOTH_EDGES`**

EXTI IRQ Handlers

- `void EXTI0_IRQHandler(void)`, line EXTI0
- `void EXTI1_IRQHandler(void)`, line EXTI1
- `void EXTI2_IRQHandler(void)`, line EXTI2
- `void EXTI3_IRQHandler(void)`, line EXTI3
- `void EXTI4_IRQHandler(void)`, line EXTI4
- `void EXTI9_5_IRQHandler(void)`, lines EXTI5 to EXTI9
- `void EXTI15_10_IRQHandler(void)`, lines EXTI10 to EXTI15

stm32_unict_lib functions to check/clear IRQs

- Check the occurrence of IRQ:

```
int EXTI_isset(EXTI_line exti);
```

  - `exti` represents the EXTI line, i.e. one of the constants **`EXTI0`**, **`EXTI1`**, ..., **`EXTI15`**

- Clear the occurrence of IRQ:

```
void EXTI_clear(EXTI_line exti);
```

  - `exti` represents the EXTI line, i.e. one of the constants **`EXTI0`**, **`EXTI1`**, ..., **`EXTI15`**

First Example: LED toggle using EXTI interrupts

```
#include "stm32_unict_lib.h"

int main()
{
    // LED at PC3
    GPIO_init(GPIOC);
    GPIO_config_output(GPIOC, 3);

    // pushbutton Y (PB4)
    GPIO_init(GPIOB);
    GPIO_config_input(GPIOB, 4);

    GPIO_config_EXTI(GPIOB, EXTI4);
    EXTI_enable(EXTI4, FALLING_EDGE);

    for (;;) { } // do nothing
}


void EXTI4_IRQHandler(void)
{
    if (EXTI_isset(EXTI4)) {
        GPIO_toggle(GPIOC, 3);
        EXTI_clear(EXTI4);
    }
}
```

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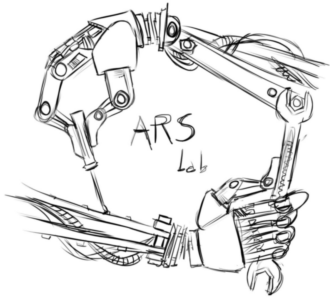

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